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Plant Material Selection and Acquisition

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Complexity	Value as a Planning Tool	Cost
Low — Moderate — High	Low — Moderate — High	Low — Moderate — High

OVERVIEW

Options for establishing vegetation along a stream corridor include (1) allowing for natural colonization, and (2) planting the desired vegetation. For viable natural colonization, there must be sources of seeds or vegetation propagules nearby that have access to the site.

If planting is necessary to establish the desired community or to accelerate the development of plant cover, species must be selected that will meet project objectives and be competitive under the site conditions. Appropriate plant materials should be selected based on the site analysis and on evaluation of the plant communities in the nearby region. A preliminary planting plan is developed consistent with project goals and objectives, site conditions, and anticipated maintenance requirements. Guidelines are prepared for the subsequent design of an irrigation system (if needed), and specific measures for plant protection are identified.

The plants must be available in adequate supply and in good condition during the planting time window. Plant material can be grown under contract, acquired through a commercial nursery, or collected from natural populations. There are trade-offs in cost, labor, and quality of plant material among the plant material sources. The site must be prepared prior to arrival of the plant material to minimize the time plants are out of the ground.

Once acquired, plants must be installed in the proper location using methods appropriate for the type of material used. Methods and procedures for installing plant materials are outlined in the planting plan. Planning also needs to take place for the maintenance of plant materials and the site during the plant establishment period and for any required or otherwise appropriate monitoring and reporting of project progress and success. Maintenance of plants through control of nuisance species, erosion, and water level in managed systems can be crucial to their survival and growth.

Figure 1. Installation of willow cuttings on the Chena River in Alaska was successful because of proper planning and care in material acquisition and handling.

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SPECIES SELECTION

Vegetation used for riparian revegetation projects usually consists of a mix of trees, shrubs, and herbaceous plants that are native to the region and well-adapted to the climactic, soil, and hydrologic conditions of the site. A botanist familiar with local flora should be enlisted to select from among candidate species those most likely to meet project objectives. The composition of the riparian community in adjacent locations can be a good guide and is often used as a starting point for the revegetation design.

Selection of plant species can be complicated by the fact that riparian communities are not always a distinct climax biotic community, however. Changes occur in species composition, diversity, structure, and function due to continual changes in site conditions. Factors originating outside the plant community (e.g., sedimentation and hydrologic alteration) and factors arising from within (e.g., increased soil fertility and shading) progressively change the habitat, allowing the plant community to evolve. On dynamic streams, floods, erosion, and deposition frequently change habitats, and the riparian vegetation may undergo perpetual succession. These influences must be considered in efforts to restore a habitat.

Recognizing that succession will occur is important because natural succession can create new communities of great value or negate the project goals and objectives. Given an adequate source of propagules, a common approach for flood control, stabilization, and restoration projects is to select and establish pioneer species on the site and allow natural succession to dictate the configuration of the vegetation community over time.

Establishing diverse vegetation, either directly or through succession, is desirable for a variety of reasons. A relatively large number of species provide an array of environmental tolerances. Fluctuations in hydrology, temperature, herbivory, and other environmental conditions will cause some plants or species to die; others may thrive. A project dominated by only one or two species may fail with the death of only one species. Planting a variety of species increases the chances for success of at least a few species.

A diverse array of plant species is essential to a riparian system's ability to provide and to sustain a number of functions. Monocultures, or communities with a single dominant species are often considered to have limited value. The establishment of a variety of desirable species will increase competition for resources and limit the potential for aggressive species to overtake a project site. In addition, a high number of plant species and structural complexity of natural ecosystems generally correlate with wildlife species richness, particularly for birds (Weins 1989).

Figure 2. A diverse assemblage of riparian vegetation optimizes benefits

Various plant species associations and hydrologic conditions provide required habitats for different life history phases of animals, such as feeding, winter cover, and breeding (Heitmeyer and Vohs 1984, Frazer, Gibbons, and Greene 1990). Maintaining a variety of vegetation types in an area enables an exchange of genetic material among neighboring populations. Migration among populations helps maintain genetic diversity and repopulation of local extinctions. Diversity can be increased at a restoration site in numerous ways, such as by

- Planting an array of different species in different amounts.
- Planting a variety of growth forms, such as, herbaceous species, ground cover, shrubs, trees, emergents, and hydrophytes.

- Planting species with a variety of life histories (e.g., annuals, short-lived or long-lived perennials).
- Providing a range of site conditions (e.g., through elevation changes, creation of habitats with varying aspects/ orientations) to support a diverse range of plant species.
- Increasing margins or edge areas.

Many flood damage reduction and restoration projects are implemented in urban environments where the landscape and environmental conditions have been altered to the degree that true restoration (achieving "natural" functions and pre-impact form) is not feasible. Under these circumstances, and in many cases where such constraints do not exist, the success of a project – as viewed by the public – is often based on the visual appeal of the site after restoration.

The landscaping component of stream and riparian restoration projects is generally under-emphasized, given its importance from the standpoint of visual success and public perception. Even projects that fully restore the desired functions for the site can be deemed a failure or a marginal success if they do not also offer visual appeal. Species should be selected to provide the necessary color, texture, and shape to meet aesthetic objectives.

Plant Material Acquisition

Plans for acquiring plants must be made well in advance of the project implementation (sometimes 1 - 2 years). If commercial plant sources are not available (USDA Soil Conservation Service, 1992), then on- or off-site harvesting can be considered. When acquiring plants, designers should be aware of local or Federal laws prohibiting the acquisition of certain plants and the decimation of natural stands of wetland plants. Additionally, care must be taken to assure that pest species are not collected and transferred to the project site.

Availability of plants of the appropriate species, size, and quality is often a limiting factor in the final selection and plant acquisition process. Some native plant species are very difficult to propagate and grow, and many desirable species are not commonly available commercially or not available as good quality plants. As demand increases and nurserymen gain more experience in growing native plant species, this limitation should become less important (Leiser 1992).

Suitable methods to acquire plants for flood control, bioengineering, and restoration projects include: a) purchase plants, b) collect plants from the wild, and c) propagate and grow plants. Each has noteworthy advantages, but also critical disadvantages that make plant acquisition and handling important and complex processes. Table 1 presents these advantages and disadvantages. Regardless of the method chosen, it is necessary to conduct the following steps (Wein and Pierce 1994, Allen and Leech 1997):

- Determine the hydrologic regime and soil types. General positioning of the plant type (e.g., emergent aquatic and shrubby willow) should be according to the plant zone (splash, bank, and terrace as characterized by Fischenich and Allen (2000)).

- Prepare a list of common riparian plants in the region and, preferably, in the watershed containing the project stream, and match those to the hydrology and soils of the project reach.

- Select species that will match the energy of the environment and the hydraulic conveyance constraints that may be imposed by the situation. Companion technical notes in this series provide guidance.

- Select species that will not be damaged by animals, especially muskrat (*Ondatia zibethieus*), nutria (*Myocastor coypes*), beaver, Canada geese, and carp (*Cyprinus carpio*). Other animals may influence plant growth and survival. If plants chosen are unavoidably vulnerable to animal damage, then protection measures such as fencing, wire or nylon cages, or repellents must be used.

Table 1. Considerations for Plant Material Acquisition

Method	Advantages	Disadvantages
Purchase	Plants are readily available at the planting location in predicted quantities and at the required time. No special expertise is required to collect or grow the plants. No wild source for the plants must be found and there are no harvesting permits to obtain from state or local governments. Cost can be more readily predicted and controllable than harvesting from the wild or growing your own.	Plants may arrive in poor condition. Selection of species is limited. Plants may not be adapted to the local environment. Cost may be high and shipping cost needs to be considered. Quantities may be limited. Storing large quantities of plants and procuring adequate and appropriate storage facilities may be necessary.
Collect From Wild	Plants are likely to be ecotypically adapted to the local environment. Plants can often be collected at a low cost. Plants can be collected as needed and will not require extended storage. Availability of species is very flexible and can be adjusted. No special expertise is required to grow the plants. A very wide diversity of plants is available.	Weedy species may be inadvertently transplanted to the project site. A suitable area or areas must be located. Plants may be stressed, diseased, or insect infested and not in an appropriate condition for planting. Rare plants or weeds may be harvested by mistake. Cost of collection and logistics may be very high. Outdoor hazards such as snakes, adverse weather, noxious plants, and parasites may interfere with collection efforts. Permits for collecting native plants may be required.
Grow	All the advantages of purchasing plants can be realized. The variety of species available can be as diverse as for plants collected in the wild and plants can be planted in large quantities. Plants that are grown can be available earlier in the season than purchased or collected plants. Low cost is one of the primary reasons to grow stock for planting.	Space and facilities must be dedicated to growing plants. Personnel with time and expertise to grow the plants may not be available. The up-front investment in both fixed and variable overhead items to establish a growing facility may not be justified unless there is a large and continuing need for planting stock.

- Determine special requirements and constraints of the site. Eliminate candidate species from the list on the basis of these constraints.
- Prepare a suite of suitable species. It may be limited to those currently available from commercial sources if there is no possibility to collect in the wild or have plants contract-grown.

Herbaceous plants are usually acquired as sprigs, rhizomes, or tubers. Seeds are best used when the threat of flooding is low in the bank and terrace zones. Woody plants used for riparian projects usually consist of stem cuttings for those species that quickly sprout roots and stems from the parent stem. These are plants such as willow, some dogwood, and some alder. They can be supplemented by bare-root or containerized stock, particularly in the bank or terrace zones where they are not subjected to frequent flooding.

Purchasing Plants

Prior to purchasing any plant materials, the design team should acquire a list of plant suppliers. The popular "Directory of Plant Vendors" (USDA Soil Conservation Service,

1992) has been updated and a recent version is available for download from: http://www.nhq.nrcs.usda.gov/BCS/PMC/pubs/wetlandvendors.html

Vendors' catalogs and plant availability lists should be consulted to determine the form of plants available from each supplier (potted, bare root, rhizomes and tubers, or seed). Match the plant list against species availability and verify that needed species will be available in needed quantities. Ordering samples, if available, to verify plant condition and identification is advisable. Contracts should include a flexible delivery schedule, allowing for unpredicted delays in planting. Some suppliers may grow plants on contract but arrangements should be made several months to a year before the plants are needed.

Collecting Plants from the Wild

Some native plant species are adapted to specific geographic areas, soil moisture conditions, and micro-environments. Collecting plants from the wild helps ensure that locally adapted plant populations (i.e., ecotypes) best suited to the site conditions are used in revegetation projects. Stock of inappropriate origin (i.e., adapted to a different environment) is likely to lower survival rates and jeopardize project success. The use of local propagules for native plant revegetation projects also maintains the integrity of the local gene pool.

Care should be taken when harvesting from the wild because of the possibility of contaminating the harvested donor plants with unwanted weedy species. Samples should be collected to identify problems that may be encountered in collecting, transporting, and storing each species. Most native plant nurseries are willing to contract to grow locally collected plant materials, and their staff may collect the necessary propagules (e.g. seeds, cuttings) and/or provide advice on the proper collection methods and timing. Other considerations are:

- Properly identify all species and avoid donor plants of unknown origin.
- Avoid collecting plant materials from isolated stands, as this may diminish genetic variability at the collection site.
- When possible, collect plant propagules either onsite or from suitable areas close to the restoration site, preferably from the same watershed.
- Match the collection and restoration sites for elevation, soils, slope, aspect, rainfall, annual temperature patterns, frost dates, and associated vegetation.
- Contact both the state Department of Fish and Game and the U.S. Fish and Wildlife Service before collecting propagules from rare plant populations.
- Obtain any required permits before collecting wetland plant materials.
- Avoid noxious or nuisance weeds that might be collected with the target plants and transported as seeds, roots, or small plants to the restoration site.
- Inspect potential collection plants for insect and disease damage.
- Always select vigorously growing, healthy-looking plants from which to harvest propagules. Avoid collecting from unhealthy or atypical plants.
- Collect equal amounts of propagules from several suitable plants and from widely spaced donor stands.
- Do not collect more than 10 percent of available seed or more than 25 percent of plants used as cuttings or for transplant from any site.
- Harvest native plant materials out of sight from the public and be considerate of the condition in which the site is left.
- Label collection bags with the species, collection site, date, and other pertinent information.

Growing Plants

Plants used for revegetation projects can be grown in a greenhouse or, in the case of emergent aquatics, outdoor ponds or troughs containing water. In either case, the plants must first be acquired and propagated. If seeds are used for propagation, they must first be stratified (subjected to various treatments such as soaking and temperature differences); however, germination requirements for many riparian and wetland plant seeds are unknown. If a greenhouse is to be used, a number of limitations and constraints must be overcome, such as room for pots, adequate ventilation,

and requirements or problems associated with fertilizing, watering, and disease and pest control. Plants can be grown in coir carpets, mats, or rolls, to facilitate early establishment, ease of transport, and rapid development. Emergent aquatic plants may be grown hydroponically and transported to the planting site ready to grow with roots already established in the carpet, mat, or roll.

Figure 3. Growing plants for restoration requires space and lead time, but can assure the proper plants are available.

HANDLING PLANT MATERIALS

Plants need to be handled carefully to ensure their survival between the phases of acquisition (purchasing, growing, or harvesting from the wild) and transplanting because they will undergo transportation and planting shock. Many problems associated with poor plant survival occur from the handling of the plants between the nursery or collection site and the project site. Generally, the live plant material needs to be kept cool, moist, and shaded. If the plants die, the bioengineering project is much more prone to failure even though dead plant materials can offer some erosion control.

Woody Plants

Woody plants, particularly cuttings, should be harvested and planted when dormant to maximize survival. Bareroot or unrooted cuttings can be stored for several months if kept in a cool, moist, and dark environment (Platts et al. 1987, Bentrup and Hoag 1998). Often, cuttings are placed on burlap and covered with layers of sawdust or peat moss and more burlap after being moistened.

Soaking cuttings prior to planting is important because it initiates the root growth process within the inner layer of bark. Both recently harvested and stored cuttings should be soaked prior to planting. Bentrup and Hoag (1998) advocate soaking cuttings for a minimum of 24 hr before planting. Some research recommends soaking the cuttings for as much as 10-14 days (Briggs and Munda 1992; Fenchel, Oaks, and Swensen 1988). Cuttings need to be removed from the water prior (usually 7 to 10 days) to root emergence from the bark (Peterson and Phipps 1976).

Ball and burlap or container plants are heavy and difficult to handle. Particular care should be exercised to ensure the bark and limbs are not damaged. When woody plants are moved from the nursery, holding, or harvesting area to the project site, they should be kept moist and free from wind desiccation. Covering the plants with a light-colored (to reflect heat) and moist tarp is recommended. Cuttings can be transported in barrels with water.

Actual planting should follow the digging of holes as soon as possible, preferably no longer than 2-3 minutes to ensure that the excavated soil does not dry out. Only moist, recently excavated soil should be used for backfill of the planting hole. Backfill should be tamped firmly to eliminate voids and to obtain close contact between the root systems and the native soils. When using containerized or balled and burlap stock, excess soil should be smoothed and firmed around the plants, leaving a slight depression to collect rainfall. These types of plants should be placed 2.5 to 5 cm (1 to 2 in.) lower than they were grown in the nursery to provide a soil cover over the root system (Leiser 1994).

Live Stakes and Posts

Cuttings to be used as live stakes and posts should be prepared from woody plants that root adventitiously (e.g., *Salix* and Populus spp.), should be obtained from as near the site as

possible, and should be free from obvious signs of diseases. The diameter of cuttings should be not less than 1 cm (3/8 in.), and larger cuttings are generally preferable. The length of cuttings should be a minimum of 30 cm (12 in.), but no shorter than is necessary to reach adequate moisture in the soil.

Cutting should be accomplished with sharp by-pass lopping shears to avoid frayed ends. The proper orientation of cuttings should be maintained by bundling the cuttings and painting the tops with a water-base paint, or by cutting the bases at an angle to facilitate driving and identify the ends.

Cuttings are best prepared just prior to placement. Cuttings prepared more than 1 week before planting should be placed in cold storage. When stored in containers, the water should be changed daily. They may be stored, wrapped in wet burlap or plastic, under refrigeration at 0 to 7 °C (32 to 45 °F).

Cuttings may be pushed into soft ground. In hard ground where this is not possible, cuttings should be planted with dibbles, star drills, or other devices to avoid damaging the bark of the cuttings. Cuttings should not be driven with hard hammers, but soft-blow hammers are acceptable. Cuttings should be placed in the ground to within 5 – 15 cm (2 - 6 in) of the tops, or should be cut leaving no more than 15 cm (6 in.) exposed. The soil should be tamped firmly around the cuttings to provide a firm hold, and no air pockets or voids should remain around the cuttings.

Fascines

Fascines should be prepared from live, shrubby material, of species that will root, such as *Salix spp.* (willow) and some *Cornus* spp. (dogwood) etc. Fascines should be prepared not more than 2 days in advance of placement when kept covered and in shade. When provisions are made for storing the fascines in water or sprinkling them often enough to keep them constantly moist, covered, and in the shade, they may be prepared up to 7 days in advance of placement.

The fascines should be laid in trenches dug to approximately one-half the diameter of the bundles. Bundles should be placed with ends overlapping at least 30 cm (12 in.) to allow the last tie on each bundle to overlap. Fascines should be covered immediately and seeped to work the soil into the bundles.

Work should progress from the bottom of the slope to the top and each row should be covered with soil and packed firmly behind and into the bundle by tamping or walking on the bundles or by both these methods. Exposure of the wattling to sun and wind should be minimized throughout the operation. Trenches should be dug only as rapidly as the wattling is being placed and covered to minimize drying of the soil in the trench and of the backfill.

Branch Packing or Brush Layering

Live, but dormant brush of willow or other adventitiously sprouting species should be used. Length of brush may vary from 0.5 to 2.5 m (2 to 8 ft) or more, depending on the installation. Cutting and handling procedures are the same as for fascines and stakes.

Hand trenching should start at the bottom of the slope. Trenches should be dug 0.5 to 1 m (2 to 3 ft) into the bank with a downward slope of 10 to 20 deg, on contour. Brush should be placed with butts into the slope with 15 to 30 cm (6 to 12 in.) of the tips extending beyond the fill face.

Brush layers should be placed on successive lifts of well-covered fill. Each layer should be covered with soil immediately following placement and the soil compacted to 85 percent of maximum. Covering may be done by hand or with machinery. Interplanting of woody plants (transplants and/or unrooted willow cuttings) and grasses should follow placement of the brush layering as specified for the site.

Ball & Burlap or Container-Grown Plants

Containerized or ball and burlap woody plants should be healthy, shapely, and well-rooted, with roots showing no evidence of having been damaged, restricted, or deformed. Containers should have a minimum size of 125 cu cm (9 cu in.) in volume and depth of 20 cm (8 in.) The growing medium should be well-drained and well-aerated. Shrub species should be

pruned during production if necessary to stimulate branching and avoid 'legginess' (i.e., bare lower stems and inability to stand upright). Containers should be transported to the project site, then placed in a shady area for 1 week prior to placement to "harden off." Containers should be kept well watered during this period.

Pits for trees and shrubs should be excavated to a minimum of 1.5 times the size of the container. The side of the pit should be vertical, lightly scarified, and the bottom should be loosened to a minimum additional depth of 15 cm (6 in.). Planting on slopes should proceed from the top to the bottom of the slope, and should be randomly staggered to avoid straight rows. Unfavorable site conditions such as rock outcroppings, existing vegetation, and structures should be avoided.

The planting should take place no longer than 2 to 3 minutes following pit excavation, and the plants should be removed from containers just prior to planting. Containers should be cut on at least two sides and removed without damage to the root ball. Some roots may need to be pruned if spiraling of the roots around the plant is causing girdling.

The plant should be set upright and in the center of the pit, then adjusted by mounding native soil in the bottom of the pit so that the root ball will be at finished grade - 2.5 to 5 cm (1 to 2 in.) lower than it was grown in the nursery, as indicated by a root collar. Fertilizer, when required, should be placed with at least 5 cm (2 in.) of soil cover and no closer than 5 cm (2 in.) to the root ball. Only the moist excavated soil should be used for the backfill. Backfill should be tamped firmly to eliminate voids and to obtain contact between the root systems and the native soils. Excess soil should be smoothed and firmed around the plants leaving a slight depression to collect rainfall.

All plants should be thoroughly watered on the day of planting. Water used in installation of plantings should be clean, clear, and free from injurious amounts of oil, salt, acid, alkali or any other toxic substance. No plants should be distributed or containers cut that cannot be planted and watered on that day. Plants that have settled should be reset to proper grade.

Herbaceous Plants

Handling requirements for herbaceous plants are more rigorous than for woody plants. They must be kept in a moist, shaded condition, or even better, in water-filled containers from the time of collection from the wild or receipt from the nursery to the time of transplanting. If herbaceous plants are identified and tagged for collection in the spring or summer, they can be collected when dormant in the late fall or winter. During those times, they can be handled more freely, but should still be prevented from drying out. Transportation from the nursery, holding, or harvesting area to the project site should be in a covered vehicle. Exposure to high winds should be avoided. Plants can be placed in a water-filled ditch and covered with soil in a shaded area for several days while awaiting planting. It is best not to store plants longer than necessary - delivery should be scheduled to match planting dates.

Plants grown in a greenhouse will require hardening. This is best accomplished before transfer to the project site if weather conditions are similar between locations, or at the site if they differ. Bentrup and Hoag (1998) stated that hardening can be accomplished by removing the plants from the greenhouse and placing them in a cool, partially shaded area for 1 to 2 weeks. A partially shaded spot near the planting site is another option. The plants should be well-watered and misted during the hardening-off period. Plants should continue to receive regular irrigation when moved from the nursery to the project site. All plants should be watered immediately before planting (i.e., the same day), so that moisture in the containers is at or near field capacity. Plants should be handled in such a way that overheating or excessive drying does not occur.

GRASS SEEDING

All seed should be delivered to the site tagged and labeled. Seed should have a minimum pure live seed content of 80 percent (percent purity *x* percent germination) and weed seed should not exceed 0.5 percent.

When preparing seedbeds, fertilizer is often mixed in with the soil when warranted. Fertilizer should be ammonium-phosphate-

sulfate and should be delivered in unbroken and unopened containers, labeled in accordance with applicable state regulations, and bearing the warranty of the producer for the grade furnished. Fertilizer should be uniform in composition, dry and free flowing, granular, or pelleted. Fertilizer should be mixed into a tilled or harrowed bed of loosely compacted soil. If seeds are to be placed in a moist zone along the stream, water-soluble fertilizers and broadcast fertilization should be avoided. Rather, side dress with time-released, low-solubility fertilizers. Fertilizer should be evenly distributed and applied less than 2 weeks prior to seeding.

Seeding should be done as early in the "planting window" as possible. Biotechnical construction and fall planting of transplants and unrooted cuttings should be done before grass seeding. If construction schedules dictate spring seeding, this seeding should be accomplished as early as possible.

Figure 4. Careful handling of plant materials will improve survival and project success.

Grass seed should be uniformly distributed at the rate (mass/surface area) recommended for the particular species used. Seed should be broadcast by mechanical trend or power-operated spreaders. The area should be hand-raked or dragged after seeding to partially cover the bed. Care should be exercised to avoid damaging the transplants and cuttings. All grass-seeded areas should be mulched within 2 working days following seeding unless prevented by weather. Straw, wood fiber, and tackifier can be used as seed mulch.

SUMMARY

If planting of vegetation or the construction of bioengineering features is a component of a restoration project, proper planning, acquisition, and handling are required to ensure success. Appropriate plant materials should be selected by a plant specialist coordinating with the design team, and be based on the site analysis and on evaluation of the plant communities in the nearby region. The planting plan must be consistent with project goals and objectives, site conditions, and anticipated maintenance requirements.

Plans for acquiring plants must be made well in advance of the project implementation, sometimes 1 to 2 years in advance. There are three suitable methods to acquire plants for flood control, bioengineering, and restoration projects: a) purchase plants, b) collect plants from the wild; and c) propagate and grow plants. Each has noteworthy advantages but also critical disadvantages that make plant acquisition and handling an important and complex process. When acquiring plants, be aware of local or Federal laws prohibiting the acquisition of certain plants and the decimation of natural stands of wetland plants. Care must be taken to ensure that pest species are not collected and transferred to the project site.

Planting a variety of species increases the chances for success and competition for resources, limiting the potential for aggressive species to overtake a project site. A high number of plant species and structural complexity of natural ecosystems generally correlate with wildlife species richness and

improve the likelihood of achieving multiple functions from the site.

In riparian ecosystems, the plant community composition and its associated habitat structure and productivity are largely determined by the timing, duration, and extent of flooding. Vegetation species and their planting position should be selected on a site-specific basis. Selection and layout of plants for flood control projects involve consideration of their resistance to stream flows and their impact on hydraulic conveyance. Thus, revegetation specifications, including species, planting location, and density, should be developed based on an evaluation of hydraulics and vegetation stability as well as the erosion control requirements, desired fish and wildlife habitat, aesthetics, plant material availability, and installation and maintenance.

Vegetation must be handled and planted properly, and with care. Many problems associated with poor plant survival occur from the handling of the plants between the nursery or collection site and the project site. Planting and seeding operations should be conducted at the optimal time. The optimal window of opportunity for most planting extends throughout the dormant winter season. Maintenance of plants through control of nuisance species, erosion, and water level in managed systems can be crucial to their survival and growth.

When plants are moved from the nursery, holding, or harvesting area to the project site, exposure of the plants to sun and wind should be minimized. Plants originating in a nursery should be hardened off. Trenches or holes should be dug only as rapidly as the plants can be placed and covered to minimize drying of the soil in the trench and of the backfill. Mulch can be applied around established plants at any time. Newly set plants should be mulched after they are planted and thoroughly watered. The mulch material may be organic such as bark, wood chips, leaves, pine needles, grass clippings or similar material, or inorganic, such as gravel, pebbles, polyethylene film or woven ground cloth. Watering and monitoring for plant health are crucial in the period immediately following installation.

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